Technical Report No. 3

AN ESSAY KEY FOR THE PHOTOIDENTIFICATION OF FARM CROPS AT SEVERAL INTERVALS DURING THE GROWING SEASON IN NORTHERN ILLINOIS

Part V

PHOTO APPEARANCE OF SMALL GRAIN FIELDS (Oats, Barley, Winter Wheat)

Project NR 387 005
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Technical Report No. 3, Part V

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By

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AN ESSAY KEY FOR THE PHOTOIDENTIFICATION OF FARM CROPS AT SEVERAL INTERVALS DURING THE GROWING SEASON IN NORTHERN ILLINOIS

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PHOTO APPEARANCE OF SMALL GRAIN FIELDS* (Oats, Barley, Winter Wheat)

Fields planted with oats, barley, or winter wheat can be identified as small grain fields on aerial photographs taken at any time during the growing season. Identification of the specific type of small grain within a single field, however, is possible only on aerial photographs taken during a relatively short period between mid-July and harvest in late July or early August. At the beginning of the growing season, fields of oats and of barley have identical photo-appearance. This appearance, moreover, is so similar to

*The facts and conclusions stated in this part of Technical Report No. 3 pertain to the photoappearance of small grain fields for the research area described in Parts I and II, a mile-wide strip extending westward from the shore of Lake Michigan at Winthrop Harbor in northeastern Illinois to within one and one-half miles of Antioch. Twenty-two fields of oats, seven fields of barley, and twelve fields of winter wheat scattered throughout this 13-1/2 square mile area were analyzed. The samples include the small grains in all possible associations with types of landforms, soils, and variations in farm practices.

The three crops are described jointly for the sake of presenting equitable comparisons regarding their photoappearance inasmuch as the three crops are nearly identical in both ground and aerial photo appearance throughout much of the growing season

that of corn fields and soybean fields that the small grains cannot be distinguished from these crops. During later intervals of growth all three of the small grains are reduced to stubble and again none has distinctive photoappearance.

Growing Small Grains in the Research Area

The growing of small grains such as oats, barley, and winter wheat is well adapted to farm practices in the research area. Barley and wheat are raised principally as cash crops. Most of the oats are fed to livestock on the farms. Oats and barley are spring-sown. Oats are planted between April 15 and May 30; barley between May 1 and May 15. The winter wheat is planted generally between September 15 and September 30. All three grains are seeded by drilling and none of the fields are intertilled. Oats and winter wheat often serve as nurse crops for new hay, but none of the barley crops are used in this way. The harvesting of all the small grain takes place near the end of July or early in August.

Individual farmers vary in their practices related to the growing of oats, barley, and winter wheat.

Farm Practices Employed in Growing Oats

The variety of oats seeded in the research area varies only slightly. Clinton No. 11 oats is planted almost exclusively. In 1950 there was only one exception; one field was seeded with Horse Mane oats. Both varieties mature in 105 days. Seeding is by small grain drill and takes place between April 15 and May 30. Oats serve as a nurse crop

for hay in about half of the oats fields in the area.

In two-thirds of the fields, oats is preceded in the rotation cycle by corn. Of these fields, half are prepared for oats seeding by spring plowing and spring disking. The other half are prepared by spring disking without plowing. In the remaining one-third of the fields, oats, barley, or hay precede oats in the rotation cycle. These fields are plowed in the fall and disked in the spring in preparation for oats seeding.

Fertilizer is applied to about forty percent of the oats fields in the area. One-half of these fields are fertilized with barn manure. Commercial fertilizers are used on the other half and consist of a mixture of 2-12-12, 2-12-6, 3-12-12, or 0-14-7.[1] Such fertilizers are applied in amounts of 150 to 300 pounds per acre.

Fields of oats are harvested by combined harvesters, by binders and threshers, or by binders and combined harvesters. Over half of the fields are harvested by combined harvesters during August. The straw is left on the ground for a day or two after harvest. It is then baled and removed from the field. The remainder of the fields are cut by binders between July 28

[1] Commercial fertilizers contain nitrogen, phosphate, and potash. Figures represent relative proportions of the three constituents. The formula 3-12-12 indicates 3 percent nitrogen, 12 percent phosphate, and 12 percent potash.

and August 17. The grain which is harvested by binders and threshers is cut, bound in sheaves, and dried in shocks in the field before threshing. Straw from fields harvested in this manner is stacked in the field or in the barnyard. Grain which is harvested by binders and combined harvesters is cut and left in swaths to dry. It is then picked up by combined harvesters and threshed.[1] Straw in fields harvested in this manner is baled and removed from the field after harvest.

Farm Practices Employed in Growing Barley

Farmers also employ different practices in the growing of barley. Two varieties of barley, Moore and Wisconsin 38, are seeded in the area. Both mature in approximately 100 days. Planting is by small grain drill and takes place between May 1 and May 15. None of the barley crops serve as a nurse crop for hay. One-half of the barley crops follow corn in the rotation cycle whereas the other half follow oats. All barley fields are seeded after fall plowing and spring disking. One-third of the crops are fertilized with 3-12-12.

Dates of barley harvest range from August 1 to August 23. Most fields are harvested by combined harvesters. In 1950 there was only one exception; a single field was harvested by

[1]The method of harvesting by binder and combined harvester is used on fields which contain many weeds. When cut and left unbound, the grain dries to the threshing stage before the weed seed is ready to thresh out. Thus the farmer can get a fairly clean yield in spite of weeds in his field.

binder and combined harvester. Barley straw is baled and removed from fields after harvest.

Farm Practices Employed in Growing Winter Wheat

Farmers also employ different practices in the growing of winter wheat. Three varieties of this crop are generally planted: Blackhawk, Mohawk, and Cherokee. Fields are seeded between September 15 and September 30. In 1950 only one field was seeded with hay. Seeding is by small grain drills. Fields are prepared for seeding by fall plowing and disking when winter wheat follows small grain in the rotation cycle. If winter wheat follows corn, disking is the only preparation needed for seeding. Approximately half of the winter wheat crops follow corn and half follow small grains in fields in the research area.

Fertilizers are applied to those fields in which the crop follows small grains in the rotation cycle. It is applied in amounts of 200 to 500 pounds per acre and consists of 3-12-12 mixture, raw rock phosphate, or barn manure. Those fields which were used for a corn crop before being seeded to winter wheat were fertilized at the time the corn was planted.

Most wheat crops are harvested by combined harvesters between July 29 and August 27. In 1950 there was only one exception; a single field was harvested by binder and thresher beginning on July 27. Straw from wheat fields which are harvested by combined harvesters is baled and removed from fields after harvest.

Photographic Qualities Which Small Grains Share With Other Crops

Small grain fields share certain photographic characteristics with other cultivated fields. These include the shape, size, and distribution of the fields. These characteristics do not change during the growing season and they can be seen on aerial photographs without the aid of a stereoscope (Fig. 3 and Figs. 9 to 17). Most small grain fields like those of hay and corn are rectangular; the few exceptions are caused by physical limitations to the crop production. Sizes of small grain fields range from five to forty acres, as do hay fields and corn fields. The larger small grain fields are used only for oats. Sizes of barley fields vary from five to twenty acres whereas sizes of winter wheat fields vary from five to twenty-five acres. On aerial photographs having a scale of 1:12,000, the smallest of small grain fields measure two-tenths by five-tenths inches; the largest oats fields measure 1.2 inches square. The largest barley and winter wheat fields, on the other hand, are only half as large.

There is no orderly distribution of small grain fields within the area. One or more of the three crops occur on nearly every farm. Oats fields are far more prevalent in the area than are barley and winter wheat fields. In the research area, oats crops rank third in total acreage. Twenty-four percent of the entire cropped land is devoted to the production of this grain. Every dairy farm, wholly within the area has one or two oats fields. This is true also of the one hog farm, the

two beef fattening farms, and four of the six cash grain farms of the area. Barley and winter wheat fields, making up approximately three percent each of total cropped land, are found on a few dairy farms but are commonly found on only cash grain farms. In 1950, only one cash grain farm in the area had neither winter wheat nor barley.

Photographic Qualities Which Differentiate Small Grain Fields From Other Crops at Selected Intervals During the Growing Season

Small grain fields can be identified on aerial photographs primarily by their unique textural properties and their unique tonal values. Objects associated with the harvesting of small grains aid in the identification of only a few small grain fields. Such objects are less prevalent than those associated with corn fields and hay fields and are less reliable than are tone and texture in identifying small grain fields.

Fields of small grain differ markedly in their textural properties before and after harvest. Plow marks, closely spaced rows of grain, and relatively short crop cover give character to their photo texture before harvest. After harvest, photo texture reflects field markings acquired by cutting and drying operations. The earlier texture is unique among crops of the area and is more definitive than the later texture.

Changes in the tonal qualities of small grain fields during the growing season present a unique progression. Tones of small grain fields are darkest in early July or when the fields have first acquired a full cover of fresh green plants (winter

wheat fields acquire such cover earlier than early July). The tones lighten as the grain matures and ripens. They are lightest when the grain is ready for harvest. In contrast, the tones of corn fields and hay fields become darker as crops mature. These latter crops acquire their darkest tones immediately before harvest (or before frost if harvest follows frost).

Criteria for the photoidentification of individual fields of oats, barley, and winter wheat are less definitive than criteria for the identification of small grain fields as a whole. Tonal differences resulting from color differences between the three crops constitute the major criteria for distinguishing one from the other. Such differences, however, are relative only during the late pre-harvest period. Winter wheat has distinctive photoappearance during the early pre-harvest period, but barley and oats have identical photoappearance at this time. At the outset of the growing season, moreover, barley and oats fields appear like fields of corn and of soybeans. Thus there are limitations to distinguishing the individual grains on aerial photographs during the early pre-harvest period. Such limitations are effective also after harvest. Color differences among small grains are no longer discernible after harvest and there are no textural differences at this time.

Photo Appearance of Small Grain Fields on May 28

On May 28, the date on which aerial photographs of the research area were first taken (Figure 9), differences can be recognized in the ground appearance of winter wheat fields

on the one hand, and in fields of barley and oats on the other. In fact, the difference between winter wheat fields and the other two grains is more noticeable on this date than at any other period during the growing season. The differences in the ground appearance, moreover, are reproduced in the aerial photographs. On the other hand, fields of oats and barley are identical in both ground and aerial photo appearance on May 28 and cannot be distinguished from each other.

Photo Appearance of Oats Fields and Barley Fields on May 28: Four characteristics mark the ground appearance of fields of barley and oats on May 28. The plants are bright green in color; bare soil appears mottled; "dead" furrow depressions extend across fields; and impressions are left by implements used in planting. The plants stand in rows spaced three inches apart and are two to three inches in height. The rows can be traced easily across fields. They are accentuated by tracks of wheels and ridges left by the small grain drill and culti-packer used in the seeding operations. The soil between the rows of plants is mottled due to differences in moisture content; it varies in color from light gray to nearly black. Dead-furrow depressions extend across fields. These are spaced at intervals of 100 to 120 feet, parallel to planted rows in some fields and at right angles to planted rows in other fields. The ratio of plant cover to bare ground is approximately one to six. Thus, the soil with its ridges, mottled colors and dead furrows dominates the overall appearance of the fields.

The ground appearance of oats and barley on May 28 is reproduced in the following manner on aerial photographs. All fields of oats and barley appear alike. Fields are marked primarily by faint, closely-spaced, parallel lines superimposed on distinctly mottled backgrounds. Secondary lines, caused by the dead-furrows, more distinct and widely-spaced, extend across the fields at regular intervals (See Plate 53 and Fig. 9, Sample 20 /4.6 - 2.7_/). In a few fields these heavier, dead-furrow lines are at right angles to the fainter, closely-spaced lines and the total effect is plaid-like (See. Fig. 9, Sample 1 /2.5 - 1.2_/). Tonal values of an individual field may range from seven to twelve on the calibrated tone scale (See Fig. 9, Sample 20 /2.5 - 0.5, 4.2 - 2.5, and 2.5 - 2.7_/, and Figs. 19 and 20). Unfortunately, because crop cover on these fields has not developed any distinctive characteristics, fields of oats and barley have the same photo appearance as do corn fields and soybean fields (Compare Fig. 9, Sample 1 /3.2 - 3.2_/ with Fig. 9, Sample 1 /3.5 - 4.2_/).

Photo Appearance of Winter Wheat Fields on May 28: Winter wheat fields are distinctive in both ground appearance and aerial photo appearance on May 28. On this date, winter wheat differs from barley and oats in height, color, and the extent to which it covers the ground. The plants are seven to eight inches tall and are yellow-green in color. Although planted in rows three inches apart, the plants appear to cover the ground. Soil mottling is, therefore, not as pronounced as in other small grain fields. Dead-furrow depressions can be traced across

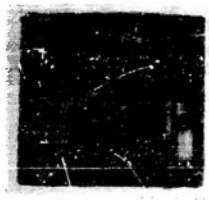


Plate 53. Oats field on May 28 has mottled and lined texture.

Plate 54. Winter wheat field on May 28 has mottled and lined texture like other small grain fields. Winter wheat fields have greater tonal contrast than other small grain fields. (See Plate 53, above).

fields but are less vivid than are those in fields of oats or barley. Like dead-furrows in other fields of small grain, these are at right angles to the planted rows in some fields and parallel to the planted rows in others.

Winter wheat fields have a photographic tonal quality darker than other small grain fields, although their texture is similar. Fields are marked by closely-spaced, parallel lines superimposed on mottled backgrounds and by heavier, widely-spaced lines which extend across fields (See Plate 54, and Fig. 9, Sample 1 /0.3 - 4.5 and 1.1 - 4.5_/). Like those in the other small grain fields, the widely-spaced heavier lines are at right angles to the closely-spaced lines in some fields and the over-all effect is plaid-like (See. Fig. 9, Sample 17 /0.5 - 0.5_/). The texture differs from that of oats and barley fields only in its intensity. It is more bold in winter wheat fields (Compare Fig. 9, Sample 1 /1.1 - 4.5_/ with Fig. 9, Sample 1 /2.1 - 5.0_/).

The distinctive tonal characteristics of the photo appearance of winter wheat fields on May 28 are threefold.

Date	Crop	Tonal Value on Fig.18	Fig. No. and Coordinates
May 28	Oats	7 to 12	Fig. 9, Samp.20 /4.2-2.5_/
May 28	Barley	7 to 12	Fig. 9, Sample 20 /2.5-0.5
May 28	Winter Wheat	7 to 13	Fig. 9, Sample 20 /1.1-4.5

In comparison with fields of oats and barley, winter wheat fields have (1) wider range of tonal variations within fields -- 7 to 13 on the calibrated tone scale -- as compared to 7 to 12 for oats and barley; (2) greater tonal contrast among the lines of fields;

and (3) less tonal contrast due to soil mottling (Compare Fig. 9 Sample 1 /1.1 - 4.5/ with Fig. 9, Sample 1 /2.1 - 5.0/). These tonal differences along with differences in textural definition enable the photo analyst to identify winter wheat fields on May 28 photographs. The limitations to the photoidentification of spring planted crops at this early period of growth are not attached to identification of winter wheat fields.

Photo Appearance of Small Grain Fields on July 8 and July 13

During the early half of July, the spring planted small grains begin to cover the ground -- a growth stage which is reached by winter wheat fields at a much earlier period and which makes it possible to distinguish winter wheat fields early in May. As a result of having acquired this growth, the three small grains bear less difference in photo texture in July than they do in May. With a few exceptions, however, each of the small grains assumes a distinctive color as it reaches the full-cover stage. These color differences among the three crops are reflected on aerial photographs by differences in tonal values which enable the photo analyst to identify each of the small grain fields in early July. Only a few exceptions to this rule occur.

Photo Appearance of Oats Fields on July 8 and July 13. Oats fields change in ground appearance between July 8 and July 13. This change, however, has little or no effect on the photo appearance of the fields on these two dates. On July 8, oats are fifteen to twenty-four inches tall and are not in head.

Plate 55. Two small grain fields on July 8. Winter wheat is in the foreground and oats in the left background. (See Plates 57, 58, 65 and 66 for photo appearance of fields of oats and winter wheat on July 8).

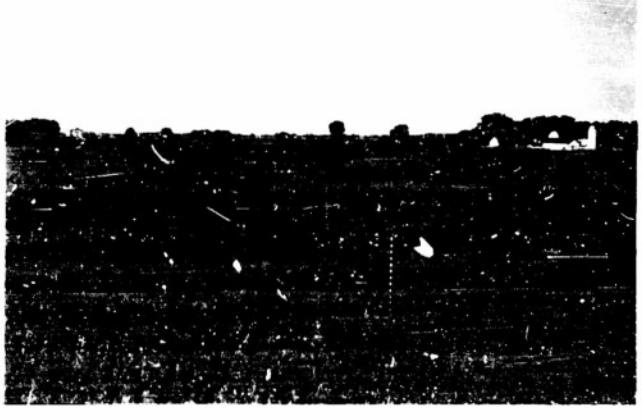


Plate 56. A field of oats in head on July 13. The forty-three inch scale shows that the plants are twenty-seven inches tall. (Photo was taken from Fig. 11, Sample 1 /0.3 - 1.0 _/)

In general, by this date, most of the fields are solidly covered with blue-green plants (See Plate 55). Some fields may be yellow-green because of excess moisture or because of the presence of mustard plants which have yellow blossoms at this time. By July 13, oats plants are twenty-four to thirty inches in height and are in head (See Plate 56). In general, fields are fully covered with either gray-blue-green or yellow-brown plants[1]. Dead furrow depressions are visible in oats fields on both July 8 and July 13 but are not so noticeable as in May. Mottling effects of the soil are hidden and plant rows are indistinct.

On July 8 and July 13 photographs (Figs. 10 and 11) fields of oats can be identified in these ways (See Plates 57 and 58): (1) by faint parallel lines superimposed on mottled backgrounds; (2) by more distinct and more widely spaced secondary lines which are either parallel to or at right angles to the faint lines; and (3) by tones which measure ten to eleven on the calibrated tone scale (Plate 57, and Fig. 19)[2]. The faint lines are finer than those in corn fields at this time (Compare Fig. 10, Sample 3 /0.3 - 1.1_/ with Fig. 10, Sample 3 /1.8 - 0.9_/ and are less distinct than those in fields of oats on May 28 (Compare Fig. 10, Sample 1 /1.0 - 3.4_/ with Fig. 9, Sample 1 /3.0 - 3.3_/ Mottling

[1]The yellow-brown color is associated with small grain rust.

[2]Tones may be slightly lighter on July 13 than they are on July 8. Tones on the July 13 photographs could not be measured quantitatively because this set of photographs is underexposed.

Plate 57. Stereopair: A field of oats on July 8 has lined and mottled texture. Dead furrow lines are at 0.3, 0.4, 0.5, 0.6 and 0.7 (left to right) and extend the full length of the field (top to bottom).

Plate 58. Stereopair: A field of oats on July 8 with plaid-like texture.

is subdued so as to be nearly lacking in some fields. The secondary lines are spaced at regular intervals. Where these are at right angles to the faint lines the overall effect is plaid-like (Plate 58 and Fig. 10, Sample 2 /0.4 - 2.9/. Here and there a nearly white line appears where a narrow strip was missed in the seeding operations. These lines tend to emphasize the lined property of fields (Fig. 10, Sample 3 /0.2 - 1.4/.

Dark tones make most fields of oats distinguishable among small grain fields on July 8. Only uncut hay fields have darker tones at this time (Compare fields in Figs. 10 and 11). Exceptions to this general characteristic are found in a few oats fields which are as light as barley fields (Fig. 10, Sample 3 /0.3 - 2.5/. Other identifying criteria are the same in both types of fields, however; so there are limitations to the identification of the two crops.

Photo Appearance of Barley Fields on July 8 and July 13. In ground appearance, barley differs from oats only in color on July 8. Barley plants are fifteen to twenty-four inches in height; they cover the ground solidly, and they are not in head. The overall color of the fields is dark yellow-green (Plate 59). Soil mottling is hidden and rows are indistinct. Dead furrows are visible but not so outstanding as they are on May 28.

On July 13, barley plants are taller than they were on July 8 and they are in head. Otherwise, fields appear as they do on July 8. Plants are now thirty to forty inches high. The overall color of fields is yellow-green (Plate 60).

FIG. MULTICOLORED

Plate 59. Barley field on July 8. Plants are fifteen inches tall and heads have not appeared. (This field appears in Plate 61).

Plate 60. Barley field on July 13. The scale in the lower right corner indicates that these plants are thirty-three inches tall. The field is in head. (This field is in Fig. 11, Sample 4 [1.2-0.4])

Similarity of ground appearance properties of fields of oats and barley on July 8 and July 13 causes a similarity of photo properties on these dates. Only the tonal qualities of the two types of fields differ perceptibly; and as noted previously, there are a few fields in which even this criteria fails.

Barley fields vary in tonal value from ten to twelve on the July 8 photographs (Fig. 20)[1]. Most of the fields, however, are of the lower or lighter tonal values in contrast to most oats fields which are of the higher or darker tonal values in a range of ten to eleven. (Compare /0.6 - 0.6/ and /2.0 - 0.6/ in Fig. 10, Sample 2; /0.3 - 3.1/, /0.3 - 2.4/, and /0.3 - 1.2/ in Fig. 10, Sample 3; and /1.0 - 0.5/ and /1.3 - 0.5/ in Fig. 10, Sample 4. Compare these same fields in Fig. 11, Samples 2, 3, and 4). A few barley fields or portions of fields have darker tonal values.

The July 8 and July 13 photographs of barley fields show faint primary lines superimposed on mottled backgrounds and more distinct secondary lines spaced at intervals of approximately one-tenth inches (Plate 61). The secondary lines are at right angles to the primary lines in some fields, giving a plaid-like appearance. Mottling is less distinct than it is on May 28. (Compare Fig. 9, Sample 20 /2.5 - 0.8/ with Fig. 10, Sample 4, /1.0 - 0.5/.

[1]Like tones of oats fields, tones of barley fields are probably a little lighter on July 13 than they are on July 8. Tones on July 13 could not be measured quantitatively.

Plate 61. Stereopair: Barley field on July 8 has mottled and lined texture. Dead furrow lines appear at 0.3, 0.4, 0.6, 0.8, and 0.9 (left to right) and extend the full length of the field (top to bottom).

Plate 62. Winter wheat field on July 8 (soybeans in foreground). The wheat is thirty to thirty-five inches tall (See Plates 65 and 66 for photo appearance on July 8).

Photo Appearance of Winter Wheat Fields on July 8 and July 13.

On July 8 and July 13, winter wheat fields continue to stand in greater contrast to the barley and oats than these grains stand in relation to each other. Winter wheat plants are thirty to thirty-five inches tall on July 8 (Plate 62) and thirty-five to forty-two inches tall on July 13 (Plate 63). Unlike oats and barley, wheat is in head on July 8. The overall color of the field changes rapidly as the grain ripens. It is light yellow-green on July 8 and light buff on July 13 (Plates 55 and 64). The crop covers the ground solidly; plant rows and dead furrows are indistinct; and soil mottling is imperceptible.

The contrast between winter wheat fields and fields of barley and oats is less striking in photo appearance than in ground appearance on July 8 and July 13. The tones of winter wheat fields are distinctive during this period but the texture does not differ greatly from that of fields of barley and oats.

Aerial photographs of winter wheat fields exhibit one or more of three textural properties on July 8 and July 13: (1) Closely spaced, faint parallel lines can be observed; (2) More distinct parallel lines, spaced at intervals of approximately one-tenth inches are apparent; (3) the mottling is rather indistinct (Fig. 10, Sample 4 /1.6 - 0.8_/). In some fields, the faint primary lines appear to rise above the mottled

Plate 63. Winter wheat field on July 13. Plants are thirty-five to forty-two inches tall.

Plate 64. Three small grain fields on July 13. Barley is in the foreground; oats are in the middle ground; and winter wheat is in the background. (Fields are in Fig. 11, Sample 4 [1.2 - 0.7], [1.4 - 0.7], and [1.7 - 0.7]).

FIG. MULTICOLORED

backgrounds so that the overall appearance is like fine corduroy cloth (Plate 65). Other fields are without textural regularity -- only fragments of lines appear here and there within these fields (Plate 66). In general, the cover on winter wheat fields appears more dense and soil mottling is less distinct than in fields of oats and barley (Compare Fig. 10, Sample 4 /1.6 - 0.8/ and Fig. 10, Sample 4 /1.2 - 0.8/.

The tonal values of winter wheat fields are distinctive on the July 8 and July 13 photographs. They are lighter than the tones reproduced by fields of oats and barley. Tones range in value on July 8 from nine to twelve (Fig. 21); most of the fields are of the lower or lighter value. On July 13 the fields are even lighter. Fields of winter wheat reproduce lighest on July 8. Oats fields possess dark tonal values at this stage of growth. A comparison shows the following densitometer rates:

Date	Crop	Tonal Value on Fig. 18	Fig. No. and Coordinates
July 8	Oats	10 to 11	Fig. 10, S. 4 /1.3 - 0.7/
July 8	Barley	10 to 12	Fig. 10, S. 4 /0.9 - 0.7/
July 8	Winter wheat	9 to 12	Fig. 10, S. 4 /1.6 - 0.7/

Photo Appearance of Small Grain Fields on July 21 and July 29

Optimum criteria for photoidentification of oats, barley and winter wheat prevail during late July when small grains ripen but are not yet harvested. Textural properties of aerial photographs of oats, barley and winter wheat during this period continue to be nearly identical as during the previous interval of growth. Some confusion carries over, also, in

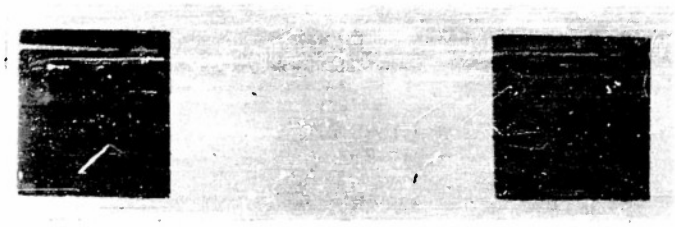


Plate 65. Stereopair: Winter wheat field on July 8 has both corduroy and plaid-like texture.

Plate 66. Stereopair: Winter wheat field on July 8 is without textural regularity.

distinguishing oats from barley. Both have similar tonal values. In general, however, each of the small grains can be identified by tonal differences. Most barley fields have lighter tones than most oats fields, whereas winter wheat fields are unique in that at this time they reproduce in the lightest tones of all fields in the area.

Photo Appearance of Oats Fields on July 21 and July 29. Two significant changes in fields of oats affect their photo appearance after mid-July. The first, a color change, acquired as the grain ripens, is general throughout the area. This change is more pronounced on the July 29 photographs than on those of July 21. The second, a change resulting from damage by storms, is localized. This change affects the photo appearance of oats fields on both July 21 and July 29 but is reflected in only a part of the fields.

The color of fields of oats changes from the yellow-brown and the gray-blue-green of July 13 to buff on July 21 and to light buff on July 29. The heads by this date are full, heavy, and approaching maturity (Plate 67).

The weight of the heads during this period makes the crop susceptible to damage by wind and rain. Here and there, sections of fields having especially luxuriant stands of grain, are flattened by such storms. Grain which is flattened at this time, moreover, does not right itself again because of the weight of the heads. Fields so damaged have a patchwork appearance.

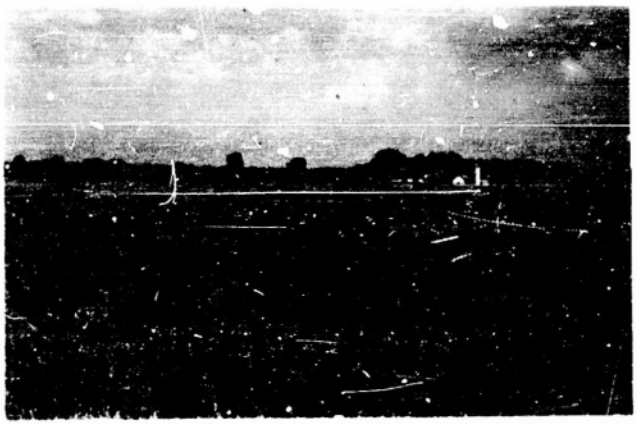


Plate 67. Oats field on July 21. The heads are full, heavy, and approaching maturity. (This field appears in Fig. 12, Sample 1 /0.3 - 1.2/

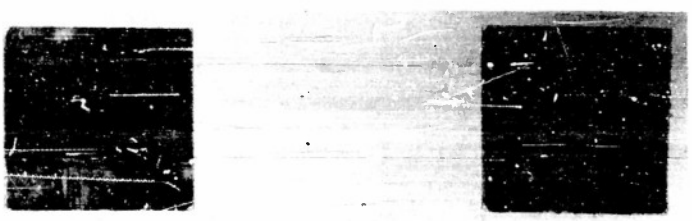


Plate 68. Stereopair: Oats field on July 21 has mottled and lined texture. Storm-damage patches appear at /0.7 - 0.7/, /0.6 - 0.3/, and /0.3 - 0.3/.

Other properties of fields of oats are much as they are on July 8 and July 13. Plant rows are indistinct, soil mottling is concealed, and dead furrow depressions are faint. The plants are approximately thirty inches tall.

Photographs of fields of oats on July 21 and July 29 differ from those taken in early July in both tonal values and texture. Tones reproduced by all fields are lighter as a result of color changes acquired with ripening; and the texture of some of the fields is patchy as a result of storm damage.

Tonal values as measured on July 21 and July 29 are eleven to twelve and eight to ten, respectively (Fig. 19). The eleven to twelve values on July 21, however, do not compare equitably with the ten to eleven values on July 8 and the eight to ten values on July 29. Excessive ground moisture following heavy rain darkened all tones on the July 21 photographs. Actually the tonal value of oats fields on July 21 should be lighter than the values on July 8 but not so light as the values on July 29. As indicated earlier, oats are ripening on July 21. As small grains ripen they go through a color sequence of decreasing tonal values. Tonal values of small grain fields on aerial photographs, therefore, should decrease with ripening. In comparison with other crops in the area on July 21 and July 29, oats fields are lighter than corn fields and uncut hay fields. They are darker than wheat fields, recently cut hay fields, and most barley fields (Compare /0.3 - 1.2_/, /0.3 - 1.8_/, /0.3 - 0.7_/, and /1.7 - 1.8_/ in Fig. 12, Sample 1; and /1.5 - 0.7_/, /1.2 - 0.7_/, and /1.7 - 0.7/in Fig. 12, Sample 4).

Storm-damage patches give a mottled quality to the photo appearance of oats fields on July 21 and July 29 (Plate 68). This mottled characteristic differs from soil mottling. The patches seem to be plastered onto the fields so that regular textural properties are disrupted. The patches differ from soil mottled areas also by being more angular in form and by having abrupt rather than gradational borders (Compare storm-damage patch in Fig. 12, Sample 2 /0.8 - 2.5/ with soil area in Fig. 12, Sample 3 /0.5 - 1.0/).

Except where disrupted by storm-damage patches, other textural properties of oats fields on July 21 and July 29 are like those in early July. Fields are lined by plant rows and dead furrows and some fields have a mottled appearance owing to soil conditions (Plate 68).

Photo Appearance of Barley Fields on July 21 and July 29. The photo appearance of barley fields differs from that of oats fields only in tone on July 21 and July 29. Textural properties of the two small grains are identical and fields of both exhibit storm-damage patches.

In ground appearance, barley fields are green to yellow-green on July 21 and yellow-green with a shiny white overcast on July 29. The shiny white property is produced by silky beards on the ripening heads of grain. These heads, like heads of oats, are heavy and full in late July making barley crops susceptible to storm damage. Patches in some of the fields are so damaged on July 21 and July 29 (Plate 69).

Barley plants are approximately thirty inches tall during this interval of growth. Plants are in rows which can be traced only faintly. Dead furrow depressions are also faint and mottling due to soil conditions is imperceptible.

An exact evaluation of the tonal properties of barley fields on the July 21 and July 29 photographs requires that consideration be given to actual densitometer values which are in millimeters (see Fig. 20). On July 21, barley fields have values ranging from nineteen to thirty-three millimeters which are generally less than the densitometer readings for oats fields ranging from twenty-six to thirty-six millimeters (Fig. 19). Readings for barley fields on July 21, like those for oats fields, should be corrected because of the excess ground moisture conditions described in the previous section on oats. On July 29, densitometer readings for barley fields range from fourteen to twenty millimeters in comparison with readings ranging from nine to seventeen millimeters in oats fields. Although the range of tones on July 29 is higher (darker) in barley fields than in fields of oats, barley fields can be described as having generally lighter tones than oats at this time. Most barley fields are of the lower (lighter) values in the range of fourteen to twenty millimeters whereas most oats fields are of the higher (darker) values in the range of nine to seventeen millimeters. Interpretation is difficult, however, because of the exceptions in the photographic reproduction of some fields of oats and barley. In comparison with other crops of the area on July 21 and July 29,

Plate 69. Barley field on July 21. Plants in the right foreground were damaged by wind and rain. (This field appears in Plate 70, below).

Plate 70. Stereopair: Barley field on July 21 has lined and mottled texture. Storm-damaged patch shown in Plate 69 appears at /0.2 - 0.3/. A large storm-damaged area appears at /0.6 - 0.4/.

barley fields are darker than wheat fields and recently cut hay fields are lighter than corn fields, uncut hay fields, and most oats fields (Compare /0.3 - 1.2_/, /0.3 - 1.8_/, /0.3 - 0.7_/, and /1.7 - 1.8_/ in Fig. 12, Sample 1; and /1.5 - 0.7_/, /1.2 - 0.7_/, and /1.7 - 0.7_/ in Fig. 12, Sample 4).

Storm-damaged patches affect the photo appearance of barley fields in late July in the same manner that these patches affect the photo appearance of oats fields. Like oats fields, barley fields are marked also by faint lines of plant rows and dead furrows and by subdued soil mottling (Plate 70).

Photo Appearance of Winter Wheat Fields on July 21 and July 29. Winter wheat fields can be distinguished from fields of oats and barley on both July 21 and July 29, because of their unique tonal qualities. On July 29 winter wheat fields have the lightest tones acquired by any crop during the entire growing season in the research area. The photographic texture of these fields, on the other hand, is much like that of oats and barley. Like these small grain fields, winter wheat fields also show storm-damaged patches.

On July 21, winter wheat fields are cream-buff in color. The plants are over forty-three inches tall. Heads of grain are heavy and bend over. Portions of several fields may be flattened by storms. Dead furrows in some fields are emphasized by dark green weeds which stand in contrast to the cream-buff of the wheat (Plates 71 and 72).

Plate 71. Winter wheat field on July 21. Depression marks a dead furrow. (This field appears in Plate 73 at /0.3 - 0.3/. The dead furrow is at /0.4 - 0.1/).

Plate 72. Three fields of small grain on July 21. Barley is in the foreground; oats in the middle ground; and winter wheat is in the background. (These fields appear in Fig. 12, Sample 2 /1.3 - 0.7/, /1.5 - 0.7/, and /1.8 - 0.7/.

Winter wheat fields have a cream-white color on July 29. The grain is ripe and a few fields are being harvested. In some harvested fields, windrows of cut grain lie in either parallel or concentric swaths. Sheaves of grain are scattered over other harvested fields.

Winter wheat fields photograph in light tones on July 21 and July 29. Tonal values range from eight to eleven and seven to eight, respectively, on these dates (Fig. 21). Like the tones of oats and barley on July 21, tones of winter wheat fields are darkened by excessive ground moisture and should be corrected slightly. On both sets of photographs, wheat fields stand in sharp tonal contrast to corn fields and uncut hay fields (Compare /2.0 - 0.1/, /2.3 - 0.7/, and /2.4 - 2.7/ in Fig. 12, Sample 2).

On the photographs, storm-damage patches and soil mottling are less vivid in winter wheat fields than in either oats or barley fields. These properties seem to be lost against the light tones of the wheat. Some of the fields are lined plainly by plant rows and dead furrows (Plate 73). Lines are less vivid in other fields (Fig. 12, Sample 4 /0.5 - 0.1/).

Harvested fields are marked by nearly white swath marks on July 29. In some of the harvested fields, the swaths form parallel bands (Fig. 13, Sample 2 /1.5 - 0.6/). In other fields, concentric bands are formed (Plate 74). Fields with the latter type of bands are also marked by an "X-like" figure which extends its arms to the four corners of the fields (Plate 74 and Fig. 13, Sample 7 /1.8 - 0.2/). The central portion of the "X" is elongated parallel to the longer sides of the fields.

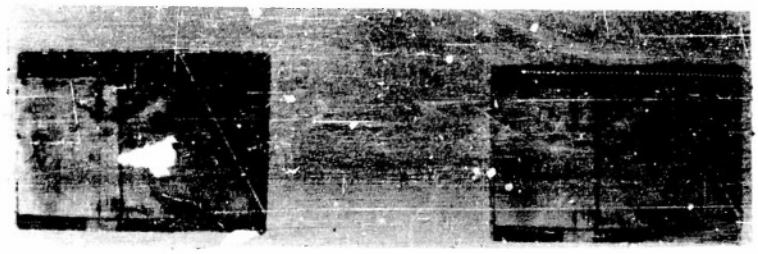


Plate 73. Stereopair: Winter wheat fields on July 21 have mottled and lined texture. Dead furrows are prominent.

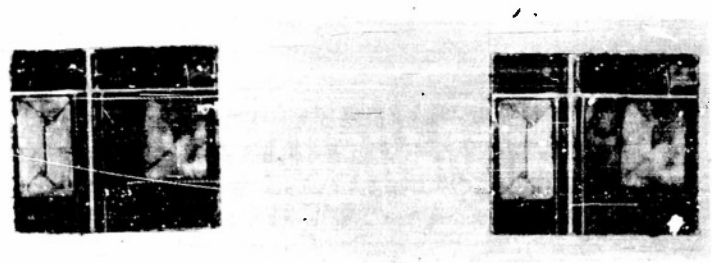


Plate 74. Stereopair: Two winter wheat fields on July 29 with harvest marks, (/0.2 - 0.4_/ and /0.8 - 0.4_/). Fields have concentric swath marks associated with an "X-like" figure with its arms extended to the four corners of the field.

A comparison of the tonal values of small grain fields on July 21 and July 29, show the following densitometer ratios:

Type of Grain	Tonal Value July 21	Tonal Value July 29	Sample
Oats	11 to 12 26 to 36 mm.*		Fig. 12, S. 2 /1.0-1.4/
		8 to 10 9 to 17 mm.	Fig. 13, S. 2 /0.5-2.0/
Barley	11 to 12 19 to 33 mm.		Fig. 12, S. 2 /1.0-0.5/
		10 to 11 14 to 20 mm.	Fig. 13, S. 2 /0.5-1.0/
Winter Wheat	8 to 11 9 to 23 mm.		Fig. 12, S. 2 /2.0-0.1/
		7 to 8 5 to 8 mm.	Fig. 13, S. 2 /1.5-0.5/

*Values in millimeters are actual densitometer measurements (See Figs. 19, 20, and 21).

Photo Appearance of Small Grain Fields After Harvest

The remaining photographs, dated September 7, September 26, October 5, and October 19, were all taken after fields of oats, barley, and winter wheat had been harvested Small grain fields can be identified as much by their post-harvest photo appearance. On the last three sets of photographs (September 26, October 5, and October 19), moreover, these fields can be classed according to three or four kinds of post-harvest conditions. At no time after harvest, however, can small grain fields be identified by grain type.[1] On the basis of post-harvest conditions, small

[1]It is even difficult to classify small grain fields by grain type on the ground after harvest. This sometimes requires searching for heads of grain which were left behind during harvest operations.

grain fields may be classified as: (1) fields which are in small grain stubble; (2) fields which are in small grain stubble and which have a new stand of hay; (3) fields which are fall plowed; and (4) fields which are fall plowed and reseeded to winter wheat. Markings of the latter two categories belong to the next cycle of growth more than to the current cycle of growth.

Photo Appearance of Small Grain Fields on September 7. On September 7, most of the small grain fields have a similar photo appearance to those fields which are in stubble. New stands of hay which give some of the fields a different appearance on later post-harvest photographs are not prominent enough to affect photo appearance on September 7 even though visible on the ground at this time. Fall plowing and reseeding to winter wheat which affect later post-harvest photographs has begun in only a few fields in the area on September 7.

Small grain fields in stubble are fields from which most of the crop cover has been removed. Only the lower four to seven inches of each plant remains. The stubble is light brown in color and stands in rows which can be traced across fields.

Small grain fields in stubble are marked by a number of features. They often contain grass growing between the rows of stubble; alfalfa and other hay plants which grow within the rows of stubble; dead furrow depressions; spots where shocks of grain stood; and markings left by harvest implements. The grass which grows between the rows of stubble is bright green. This green is concentrated in patches in some fields more than

in others. Such fields have, as a result, a mottled light brown and bright green color. Grass is concentrated especially in dead furrow depressions and in spots where shocks of grain stood before being harvested. Shocks leave spots which are three to four feet in diameter. In some of these spots, the grass is bleached to a light yellow-green.[1] Alfalfa and other hay plants can be found in some of the fields of stubble but do not affect the overall appearance of the fields. Harvest implements mark fields of small grain stubble in two ways. Many of the fields are banded by one or more of the implements which cut the grain, thresh the grain, rake the straw, or bale the straw (Plate 75). These bands are concentric in some fields and parallel in others. Less prevalent are wagon trails which cut across fields haphazardly converging at lanes leading to barns. In three fields, wagon trails converge at a straw stack.[2]

On the September 7 aerial photographs, fields of small grain stubble can be identified by their relatively light tones[3]

[1]Spots left by shocks are found only in fields harvested by binder and threshing machine.

[2]Straw stacks indicate that the grain was threshed by means of a threshing machine.

[3]Tones could not be measured quantitatively on this set of photographs because they are underexposed. The sample strip used in the study, moreover, was missed by the photographers and control points for correcting the tonal readings so that they would be relative to those on other sets of photographs were not available. The September 7 photographs show the adjoining mile-wide strip to the south of the research area.

Plate 75. Swath marks in a small grain field which is in stubble on September 7. (For photo appearance see Fig. 14, Sample 12 /2.0 - 0.4_/ and /2.0 - 0.8_/

and a variety of textural properties. The tones of these fields are generally darker than those in recently cut hay fields but lighter than those in uncut hay fields and corn fields on September 7 (Compare /1.1 0 1.8/, /0.1 - 2.2/, /0.5 - 2.4/, and /0.5 - 1.7/ in Fig. 14, Sample 13). The few fields which may appear as light as recently cut hay fields can be identified on the basis of texture.

Fields of small grain stubble are easily identified in photo appearance on September 7 by their mottled appearance. This mottling is likely to be more complex than that on earlier photographs. Soil differences in fields form mottled areas which are somewhat rounded; and in the same fields, concentrations of green grass in dead furrows and in spots left by shocks form mottled areas arranged in a row. (Plate 76). Fields of small grain stubble having tones as light as those in recently cut hay fields can be identified primarily on the basis of this mottled appearance.

Lines in fields of small grain stubble constitute another outstanding identifiable feature of these fields on the September 7 photographs. These lines reflect rows of stubble and dead furrows and are spaced as on earlier photographs. Row lines are fine and closely spaced. Dead furrow lines are more pronounced and spaced at intervals of one-tenth inches (Plate 76).

Four features are reflected in only a part of the fields of small grain stubble on the September 7 photographs. These features are: (1) banding with bands across a few fields (Plate 77),

but in the greater number of fields, the bands form a concentric pattern associated with an X-like figure extending its four arms to the four corners of the fields (Plate 78); (2) rows of fine dots, some dark and some light, left by shocks of grain[1]; (3) straw stacks which appear as lumps with light tones and crescent-like shadows[2]; and (4) wagon trails which have light tones and which converge at straw stacks or at lanes leading to the buildings of the farmstead[3]. Rows of dots and stacks of straw are found only in fields which are harvested by a binder and threshing machine, whereas concentric banding is more likely to be found in fields which are harvested by combined harvester.

Photo Appearance of Small Grain Fields in Stubble During the Later Post-Harvest Period. Little change is recorded in either the ground or the photo appearance of small grain fields in stubble after September 7. Only two conditions which characterize the ground appearance of these fields change during this period. On September 26, October 5, and October 19, the overall color of the fields is more uniform and rows of stubble

[1]At a scale of 1:14,400, there are approximately eight of these to one-tenth of an inch (Plate 76 and Fig. 14, Sample 10, /1.7 - 0.6_/.

[2]These measure approximately one-twentieth of an inch in diameter at a scale of 1:14,400 (Fig. 14, Sample 10 /1.5 - 0.7_/

[3]These measure approximately one-fiftieth of an inch across at a scale of 1:14,400 (Plate 77 and Fig. 14, Sample 10, /1.5 - 0.7_/.

Plate 76. Stereopair: Field of small grain stubble on September 7 has mottled, lined, and dotted texture. Soil-mottled areas are rounded /0.2-0.9_/. A vegetation-mottled area forms a broken line extending from /0.3-0.9_/ to /0.3-0.4_/. Vegetation mottling is found also in aligned dots at /0.15-0.3_/. Rows of stubble can be traced at /0.4-0.5_/. Dead furrows extend from the north to the south edges of the field at 0.2, 0.3, 0.4, 0.5, and 0.6 (left to right).

Plate 77. Stereopair: Field of small grain stubble on September 7 is marked by parallel bands and wagon trails which converge at the gate which open onto the public road.

Plate 78. Stereopair: Field of small grain stubble on September 7 has concentric swath marks and an X-like figure with arms extended to the four corners of the field.

and banding by harvest implements are less distinct than on September 7. Both changes are affected by widespread growth of grass (and weeds). The overall color of fields is green and dull brown on September 26 and October 5. On October 19, the overall color is yellow-brow, a change resulting from frost.

Aerial photographs taken on September 26, October 5, and October 19 reflect the changes acquired in the ground appearance of fields in stubble after September 7. During the later period, mottling and banding of fields becomes less distinct; tones darken and then lighten; and some of the light dots left by shocks of grain become dark. The darkening of tones in fields of stubble increases from harvest until frost. Tones are darker on September 26 than on September 7 and are still darker on October 5.[1]. Frost causes a slight lightening of tones so that they are lighter on October 19 than on October 5. In comparison with other fields on September 26 and October 5, most fields of stubble are darker than newly plowed fields and fields reseeded to winter wheat, and lighter than corn fields, old hay fields, and stubble fields which have new stands of hay. These facts may be ascertained by comparing the following fields in

[1]Tonal values of small grain fields as given in Figs. 19, 20, and 21 are of little significance when analyzing fields according to specific conditions on September 26, October 5, and October 19. In each instance, a range of tones is given which includes fields which are in stubble, fields which are in stubble and a new stand of hay, fields which are fall plowed, and fields which are fall plowed and reseeded to winter wheat.

Fig. 16: /1.7 - 0.3_/ and /0.3 - 1.2_/ in Sample 1; /2.0 - 1.8_/ and /1.8 - 0.9_/ in Sample 19; /1.0 - 1.1_/ and /0.3 - 2.1_/ in Sample 3; and /2.3 - 0.2_/ in Sample 18.

On October 19, fields of stubble have about the same tonal value as corn fields. This is shown by /0.3 - 2.8_/, /1.3 - 2.6_/, /0.3 - 1.2_/, and /2.0 - 1.2_/ in Sample 3, Fig. 17. Hay fields and fields of stubble with new hay are darker whereas plowed fields and those which have been reseeded are lighter than fields of stubble on October 19. This can be seen by comparing the following fields in Fig. 17: /0.3 - 1.2_/ and /1.3 - 1.2_/ in Sample 3; /1.0 - 1.4_/, /0.3 - 0.3_/, and /2.1 - 2.4_/ in Sample 18; and /2.0 - 2.2_/ in Sample 19.

Other photo properties of fields of stubble on September 26, October 5, and October 19 are like those on September 7. Although less distinct than on September 7, mottling and banding help the photo interpreter identify these fields during the later post-harvest period (Fig. 17, Sample 3 /0.4 - 2.9_/). Fields are lined by dead furrows (Fig. 17, Sample 3 /0.3 - 1.2_/; and dots where shocks of grain stood before being threshed mark those fields which were harvested by binder and threshing machine (Fig. 17, Sample 18 /1.1 - 1.3_/.

Photo Appearance of Small Grain Fields Which Have New Stands of Hay During the Later Post-Harvest Period. The ground appearance and the photo appearance of small grain fields which have a new stand of hay are such that these fields can be identified with relative ease and accuracy on September 26, October 5, and October 19. These fields differ from stubble fields without

new hay in color and in density of ground cover. Inasmuch as most hay crops in the area consist either wholly or partially of alfalfa, the color of most small grain fields having new stands of hay is deep dark-green. Hay covers the fields more solidly than does the haphazard growth of grass and weeds found in stubble fields without new hay. As the new hay grows it tends to obscure mottling, implement banding, rows of stubble, and round spots left where shocks of grain stood before being threshed just as harvest banding tends to be obscured by regrowth of hay after harvest in the old hay fields.

Small grain fields which have new stands of hay can be identified by both tonal and textural properties on the later post-harvest photographs. In comparison with stubble fields without new hay, the fields with new hay have darker tones but nearly the same textural properties. To see this, compare /0.2 - 1.5/ and /0.5 - 2.2/ in Sample 2, Fig. 14; /1.7 - 0.2/ and /1.6 - 1.3/ in Sample 15, Fig. 15; /2.3 - 1.1/ and /2.3 - 0.3/ in Sample 18, Fig. 16; and /0.7 - 1.5/ and /0.3 - 0.5/ in Sample 18, Fig. 17. Textural properties may be less distinct in some of the new hay fields than those in fields of stubble without new stands of hay. In comparison with old hay fields, the new hay fields have nearly the same tonal values but different textural properties. This can be seen by comparing /0.7 - 1.3/ and /1.6 - 1.3/ in Sample 15, Fig. 15; /1.5 - 2.0/ and /2.3 - 0.3/ in Sample 18, Fig. 16; and /0.3 - 0.5/ and /2.5 - 0.5/ in Sample 18, Fig. 17. The different textural properties are especially clear in spots

of thin cover which appear here and there in the new hay fields. The texture of such spots definitely indicates that these fields are associated with small grain stubble (Plate 79).

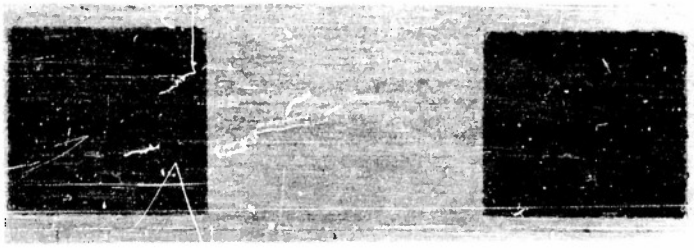


Plate 79. Stereopair: New hay field on October 5 has thin cover areas which show texture of small grain stubble.

Photo Appearance of Small Grain Fields Which are Fall Plowed During the Later Post-Harvest Period. Fall plowing in fields of small grain removes all traces of the properties previously associated with small grain fields. New properties acquired through plowing, however, enable the photo analyst to identify these fields readily. Moreover, the photo analyst is reasonably safe in assuming that fields which are fall plowed before October 19 had been used for one of the small grain crops earlier in the growing season. During the time of this study, thirty-nine small grain fields were fall plowed prior to October 19. Some of these were plowed prior to September 26. Fall plowing in other fields prior to October 19 was limited to one rotation pasture, parts of two corn fields, and parts of two

hay fields.[1] None of these were plowed before September 26 but three were plowed between September 26 and October 5.

Plowed fields, as seen on the ground on September 26, October 5, and October 19, are marked by parallel ridges of loose soil, dead furrows, and soil mottling (Plate 80).

Plate 80. Fall plowed field in early September. The scale stands in a dead furrow. (For photo appearance of fall plowed field on September 7 see Fig. 14, Sample 11 /1.0 - 0.5/).

The parallel ridges, approximately fifteen inches wide, overlap slightly and extend the full length (or breadth) of the fields. Dead furrows, approximately thirty inches wide, parallel the ridges. They disrupt the continuity of ridges at intervals of 100 to 120 feet. The soil is mottled by differences in moisture

[1]A few crops of winter wheat follow corn in the rotation cycle. Preparation for seeding of these fields consists usually of disking without plowing inasmuch as the soil in corn fields has been kept relatively loose (uncompact) by intertillage of the corn.

content. Well drained areas are light gray in color whereas poorly drained areas are nearly black in color.

The ground appearance of plowed fields is reflected on the aerial photographs taken after harvest. The most outstanding of the photo properties is mottling. This property enables the photo analyst to locate plowed fields fairly accurately without the aid of a stereoscope (Fig. 15, Sample 16 /1.8 - 0.5_/; Fig. 16, Sample 4 /0.5 - 0.2_/; and Fig. 17, Sample 18 /2.0 - 2.2_/) When viewed with a stereoscope, plowed fields are found to be marked by faint parallel lines which are closely spaced and by more distinct parallel lines, some appearing like grooves (Fig. 17, Sample 18 /2.1 - 2.4_/). Within fields, tones vary from dark gray to nearly white. Areas of light tones are the whitest of all tones found on aerial photographs taken late in the season (Fig. 17, Sample 18 /2.0 - 2.8_/).

Photo Appearance of Small Grain Fields Which are Reseeded to Winter Wheat During the Late Post-Harvest Period. Eleven of the small grain fields which were fall plowed in the research area were reseeded to winter wheat. Marks left in these fields by the small grain drill and the growth of the new wheat plants give these fields a unique ground appearance during the late post-harvest period. The photo appearance of these fields, however, differs little from that of plowed fields on September 26, October 5, and October 19.

Fields planted to winter wheat are marked by fine parallel lines, dead furrows, and soil mottling on September 26. The dead furrows and soil mottling are like those of the plowed

fields. The lines, however, are unique features of fields planted to wheat at this time. These lines are spaced three inches apart and replace the ridges found in fall plowed fields. The ends of these lines turn in a festoon-like pattern at the two ends of some of the fields (Plate 81). At the ends of other fields, a set of lines ten to twenty feet wide cross the main body of lines at right angles.

Plate 81. Field planted to winter wheat on September 26. Festoon-like marks were formed by the drill as it was turned around at the edge of the field.

By October 5, new wheat plants appear in the drill lines. These plants are one to two inches tall and can be traced easily across fields (Plate 82). By October 19, the plants are approximately three inches tall. The ratio of plant cover to bare ground at this time is about one to one (Plate 83).

The photo appearance of fields reseeded to winter wheat is marked by soil mottling, dead furrows, and faint lines. These fields differ from plowed fields by slightly smoother

Plate 82. Field of winter wheat on October 5. This field appears in Fig. 16, Sample 19 /2.3 - 1.8/

Plate 83. Field of winter wheat on October 19. (This field appears in Fig. 17, Sample 19 /1.4 - 1.4/

texture and by festoon-like turnings at the ends of the main body of lines in some fields (Fig. 17, Sample 19 /2.0 - 1.9_/) and by a band of lines crossing the ends of the main body of lines in other fields (Fig. 17, Sample 19 /1.4 - 1.8_/). These fields have a smoother texture than plowed fields as a result of the levelling of plowed ridges by disks and culti-packers. Dead furrows appear but not with the groove-like quality of dead furrows in plowed fields (Fig. 17, Sample 19 /2.1 - 2.5_/). Mottling and tonal values in fields are alike for seeded fields and fall plowed fields.

The Effect of Farm Practices on the Aerial Photo Appearance of Small Grain Fields

Variations in farm practices employed in the growth and harvest of a given type of small grain (oats, barley, or winter wheat) have only minor effects on the photo appearance of those small grain fields. The effects are limited to photographs taken during and after harvest (July 29 to October 19) and depend on variations in harvest dates, harvest methods, and on whether or not they are used as nurse crops for new hay.

Variations in harvest dates are indicated on the July 29 photographs. Some wheat fields, for example, are harvested on July 29. The photo appearance of these fields is marked by nearly white swath marks forming either parallel or concentric bands. Other wheat fields are not harvested on July 29. On photographs these fields are marked by lines and a mottled texture and register the lightest tones on the photographs at this time.

Indications of variations in methods of harvest are found primarily on photographs taken after harvest. Some fields of oats, for example, are harvested by binder and threshing machine. On photographs these fields are characterized by faint parallel lines, distinct mottling, and rows of dots where shocks of grain stood before being threshed. Straw stacks and wagon trails can also be found on the photographs of some of these fields. Other fields of oats are harvested by combined harvester. These fields are marked on the photographs primarily by concentric swath marks and an X-like figure with its arms extended to the four corners of the fields.

Variations in the uses of small grains as nurse crops for new hay affect the post-harvest appearance of small grain fields. Those fields having new stands of hay have generally darker tones and less pronounced textural properties than do the small grain fields without new stands of hay.

Among the fields of a particular type of small grain, photo appearance is unaltered by variations in planting dates, planting methods, seed varieties, field uses during the previous year, field preparations for planting, and applications of fertilizer.

Conclusions

An examination of the photo appearance of small grain fields (oats, barley, and winter wheat) at nine intervals of growth from May 28 to October 19 reveals that: (1) these fields can be identified as small grain fields at nearly all intervals of growth; (2) winter wheat fields can be distinguished at all

intervals of growth prior to harvest; (3) oats fields and barley fields can be distinguished accurately at only those intervals between mid-July and harvest; (4) small grain fields can be identified as such on the basis of their textural properties; and (5) each of the three types of small grain fields can be distinguished on the basis of their tonal properties.

Small grain fields have four characteristics which they share in common with other cropped fields in the research area and which are of little help to the photo analyst:

(1) Small grain fields are of the same size and form as other cropped fields;

(2) The photo appearance of small grain fields is not affected by variations in land forms and soils and by most variations in farm practices;

(3) Small grain fields pass through only one cycle of growth and harvest during the growing season; and

(4) There are periodic limitations to the identification of small grain fields on aerial photographs.

Small grain fields have five characteristics which distinguish them from other cropped fields on aerial photographs. These characteristics are:

(1) At all but the earliest interval of growth small grain fields have unique textural properties;

(2) Each of the three types of small grain fields has unique tonal properties by which it can be identified during certain intervals of growth;

(3) Tones of small grain fields are light at early intervals of growth, are relatively dark at intermediate intervals of growth (early July), and turn progressively lighter during the intervals between mid-July and harvest (other crops darken with maturity);

(4) Small grains are harvested earlier than other crops having a single cycle of growth and harvest; and

(5) Small grain fields are fall plowed earlier than other fields in the area.

In addition to the five photo characteristics which distinguish small grain fields in general, winter wheat fields possess three characteristics which are not shared by oats fields and barley fields:

(1) Winter wheat fields have unique textural properties during the earliest interval of growth;

(2) Just before harvest, winter wheat fields acquire the lightest tones which are acquired by any cropped fields at any interval of growth; and

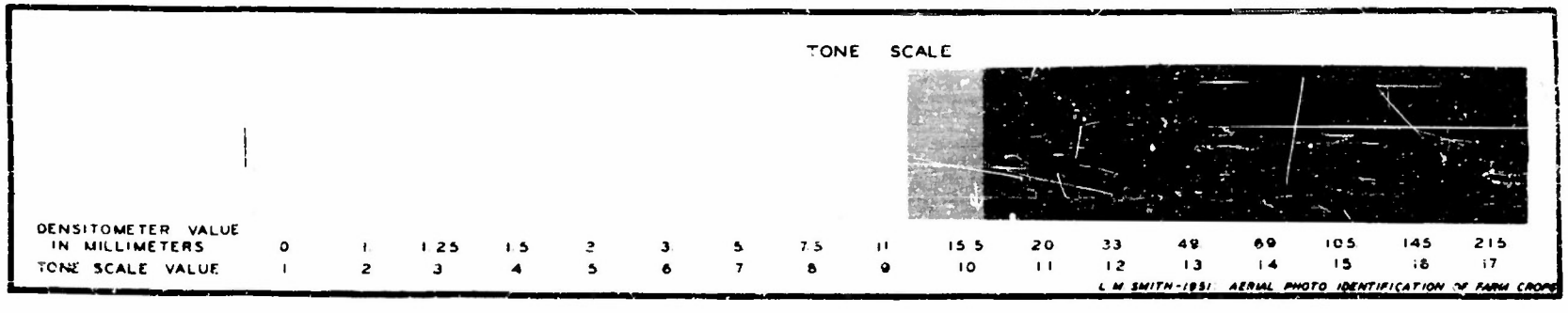
(3) Fields which will be used for winter wheat during the next succeeding cycle of growth are planted in the fall and acquire unique textural properties on the October photographs.

KEYS FOR THE AERIAL PHOTO IDENTIFICATION OF OATS
BY STAGES THROUGHOUT THE GROWING SEASON

	May 28 Three to Four Weeks After Planting (1) (See Fig. 9)	July 6 Nine to Ten Weeks After Planting (2) (See Fig. 10)	July 13 Ten to Eleven Weeks After Planting (3) (See Fig. 11)	July 21 Eleven to Twelve Weeks After Planting (4) (See Fig. 12)	July 29 Twelve to Thirteen Weeks After Planting (5) (See Fig. 13)	September 7 Three to Five Weeks After Threshing (6) (See Fig. 14)	September 26 Six to Eight Weeks After Threshing (7) (See Fig. 15)	October 5 Nine to Eleven Weeks After Threshing (8) (See Fig. 16)
Tone Densitometer value Tone scale value	7 to 12 (subjective value)	14 to 22 10 to 11	*	26 to 36 ** 11 to 12	9 to 17 8 to 10	*	8 to 17 8 to 10	Tones of 10/19 11 to 26 10 to 21 9 to 12 9 to 11 (See Fig. 15)
Form and size	Rectangular--5 to 40 acres							
Shadow								
Texture	Very faint parallel lineation superimposed on a mottled background. Faint secondary lineation at right angles to primary lineation gives a plaid-like appearance to some fields.	Fine parallel lineation on a mottled background. Some fields will show lines at regular intervals more pronounced than those on either side. (Such lines coincide with dead furrows made when field was plowed.) Lineation is finer than that of corn. Faint secondary lineation at right angles to primary lineation may give a plaid-like appearance to some fields. Lineation is especially pronounced in the darker portions of mottled background. Bold white lines appear where planter missed a narrow strip in the seeding process. Mottling is not so intricate as that of the previous stage.	Fine parallel lineation on a background of subdued mottling -- very much like texture of the nine to ten weeks stage.	Very fine lineation on a background of subdued mottling. In some cases mottling may be obliterated. Very much like corn in its resemblance to corduroy cloth. Oats gives a finer corduroy appearance than corn. Locally there is mottling of very great contrast resulting from storm damage. Heavy growth (usually in edge where there has been more moisture available for growth) is easily knocked over by heavy rain and wind.	Much like texture of the previous stage except soil mottling (associated with the sag and swell of the terrain) is alternated in many cases. Storm mottling is discernible.	Fine parallel or concentric lineation on a mottled background. In fields with concentric lineation a huge X reaches to the four corners of the field. Corduroy texture has disappeared with cutting of the crop. Rows of fine white dots at right angles to lineation mark spots where sheaves of grain lay or where shocks of cut grain stood (in the case of crops harvested by binder and threshing machine.) Where crops were harvested by combined harvester parallel bands of white may appear. These are windrows of straw lying ready to be baled.	Texture is like that of the previous stage. Rows of white dots at right angles to lineation have given way to rows of dark dots in some fields. Some of the fields of stubble have been fall plowed. The texture of such fields is that of very faint lineation on a distinctly mottled background. Other fields which had been seeded with hay are now identified as hay -- their appearance is that of uncut hay.	Oats fields can now be divided into three groups: (1) those which have been fall plowed; (2) those with a dark uncut hay appearance; and (3) a few which are in stubble which will be fall or spring plowed. Some of the fall plowed fields have been replanted to winter wheat which now stands from two to three inches tall. In such cases photo appearance is much like that of the early spring stage of winter wheat -- twelve to thirteen weeks prior to threshing.
Relation to associated features						May be associated with new straw stacks in the field. Wagon tracks may converge at straw stack or at a lane leading to barns. (New straw stacks are white lumps approximately one twentieth of an inch in diameter on aerial photographs having a scale of 1 to 14,500. They are marked by crescentic shadows.)	Associated features are those of the previous stage -- column d.	Associated features are those of the previous two stages.
Pattern	No orderly arrangement of field distribution. This is one of the basic crops of the area and is found on nearly every farm.							
Limitations	Oats cannot be distinguished from other spring sown crops -- barley, corn, and soybeans.	Fields of oats are now darker than other spring planted crops and winter wheat. A few fields of oats may still look like barley. Wheat lineation is more pronounced in light portions of the mottled background.	Differentiation between barley and oats is still difficult. In most cases oats are darker than barley but a few fields are exceptions to this tendency.	Tone of oats is only slightly darker than that of barley.	Limitation is that of the eleven to twelve weeks stage -- column 4.	Harvested small grains (oats, barley, and wheat) have the same photo appearance. In this area all are harvested throughout the same period.	See column d.	See column d.

*Tones could not be graded.
**Tone is exaggerated in darkness as a result of excess ground moisture after rain.

Figure 19

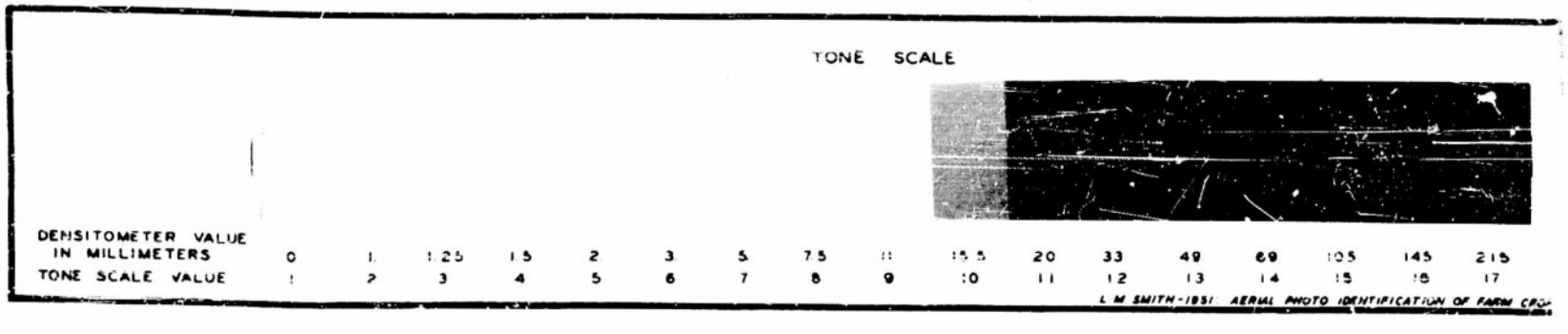


KEYS FOR THE AERIAL PHOTO IDENTIFICATION OF BARLEY
BY STAGES THROUGHOUT THE GROWING SEASON

	May 20 Two to Four Weeks After Planting (1) (See Fig. 9)	July 8 Eight to Ten Weeks After Planting (2) (See Fig. 10)	July 15 Nine to Eleven Weeks After Planting (3) (See Fig. 11)	July 21 Ten to Twelve Weeks After Planting (4) (See Fig. 12)	July 29 Eleven to Thirteen Weeks After Planting (5) (See Fig. 13)	September 7 Two to Three Weeks After Threshing (6) (See Fig. 14)	September 26 Five to Six Weeks After Threshing (7) (See Fig. 15)	October 5 Six to Seven Weeks After Threshing (8) (See Fig. 16)
Tone Densitometer value Tone scale value	7 to 18 (subjective value)	14 to 39 10 to 18	*	19 to 33 ** 11 to 12	14 to 20 10 to 11	*	6 to 17 7 to 10	Tones of 10/19 11 to 22 10 to 14 9 to 11 9 to 10 (See Fig. 15)
Form and size	Rectangular--6 to 40 acres							
Shadow								
Texture	Very faint parallel lineation superimposed on a distinctly mottled background.	Fine parallel lineation on a mottled background. Locally there may be secondary parallel lineation at right angles to the primary lineation. This gives a plaid-like appearance to fields. Some fields will show lines at regular intervals which are more pronounced than those on either side. Mottling is less pronounced than that of the two to four weeks stage -- column 1.	Fine parallel lineation on a background of subdued mottling.	Very fine parallel lineation on a background of subdued mottling. Locally a new kind of mottling comes into small grains at this stage in their growth -- mottling resulting from storm damage. Heavy growth (usually in sags where there has been more moisture available for growth) is easily knocked over by heavy rain and wind.	Texture is that of the ten to twelve weeks stage -- column 4.	Parallel or concentric lineation on a background with little or no mottling. In fields with concentric lineation a huge X reaches to the four corners of the field.	Some fields of stubble have been fall plowed. The texture of such is that of very faint lineation on a distinctly mottled background.	Some of the fall plowed fields have been replanted to winter wheat which now stands from two to three inches tall. In such cases photo appearance is much like that of the early spring stage of wheat -- twelve to thirteen weeks prior to threshing
Relation to associated features								
Pattern	No orderly arrangement of field distribution. This is one of the basic crops of the area and is found on nearly every farm.							
Limitations	Barley cannot be distinguished from other spring sown crops -- oats, corn, and soybeans.	At this stage texture of oats and barley remains the same. Distinguishing between the two continues to be difficult. In most cases barley has lighter tone than oats.	Limitation is that of the eight to ten weeks stage -- column 2.	See column 2.	See column 2.	Harvested small grains (oats, barley, and wheat) have identical photo appearance.	See column 6.	See column 6.

*Tones could not be graded.
**Tone is exaggerated in darkness as a result of excess ground moisture after rain.

Figure 20



KEYS FOR THE AERIAL PHOTO IDENTIFICATION OF WINTER WHEAT
BY STAGES THROUGHOUT THE GROWING SEASON

	May 28 Twelve to Thirteen Weeks Before Threshing (1) (See Fig. 9)	July 8 Six to Seven Weeks Before Threshing (2) (See Fig. 10)	July 13 Five to Six Weeks Before Threshing (3) (See Fig. 11)	July 21 Four to Five Weeks Before Threshing (4) (See Fig. 12)	July 29 Three to Four Weeks Before Threshing (5) (See Fig. 13)	September 7 One to Two Weeks After Threshing (6) (See Fig. 14)	September 26 Four to Five Weeks After Threshing (7) (See Fig. 15)	October 8 Seven to Eight Weeks After Threshing (8) (See Fig. 16)
Tone Densitometer value Tone scale value	7 to 13 (subjective value)	11 to 34 9 to 12	*	9 to 23 ** 8 to 11	5 to 8 7 to 8	*	13 to 15 9 to 10	Tones of 10/19 15 to 24 7 to 14 10 to 11 8 to 10 (See Fig. 18)
Form and size	Rectangular--5 to 40 acres							
Shadow								
Texture	Very distinct parallel lineation superimposed on a mottled background. Some lines at regular intervals stand out more boldly than those on either side. (Such lines coincide with dead furrows made when the field was plowed.) Faint secondary lineation at right angles to primary lineation may give a plaid-like texture to a field. (In this case the field was plowed and disced in one direction. Wheat was drilled at right angles to plowing and disking.)	Much like textures of the previous stage except that lineation and mottling are subdued. Locally the stereoscopic appearance may resemble corduroy cloth. Locally the only lines discernible are those coincident with dead furrows.	Very subdued lineation and mottling.	Parallel lineation.	Faint parallel lineation where uncut. Concentric swathe around field where crop is being cut. Cut grain may lie in windrows where cut with a binder and being dried for later harvesting by a combined harvester. Windrows may be parallel across a field or concentric around a field. Concentric texture is associated with a huge X with its four arms extending to the four corners of the field.	Fine parallel lineation on a mottled background. In fields of concentric lineation a huge X reaches to the four corners of the field. Corduroy texture disappeared with cutting of the grain. Rows of fine white dots mark spots where sheaves of grain lay or where shocks of grain stood in the case of crops cut by binder and threshed by threshing machine.	Some fields which had been fall plowed. In such cases texture is made up of very faint parallel linertion on a distinctly mottled background.	Some of the fall plowed fields have been reclanted to winter wheat which now stands from two to three inches tall. In such cases photo appearance is much like that of the early spring stage -- twelve to thirteen weeks prior to threshing -- column 1.
Relation to associated features						No straw stacks were found associated with wheat fields in the area as were found in the case of oat fields.		
Pattern	No orderly arrangement of field distribution. This is one of the basic crops of the area and is found on nearly every farm.							
Limitations	There are, in this area, three fields of winter rye which have the same photo appearance as wheat. Generalizations about differentiating between the two crops cannot be made on the basis of only three fields of rye. In texture winter wheat is also like oats and barley. At any given stage the tone of winter wheat differs from that of oats and barley.	Limitations are those of the previous stage -- column 1.	Limitations are those of the previous stages.	Limitations are those of the previous stages.	Limitations are those of the previous stages.	Harvested small grains (oats, barley, and wheat) have identical photo appearance.	See column 6.	See column 6.

*Tones could not be graded.
**Tone is exaggerated in darkness as a result of excess ground moisture after rain.

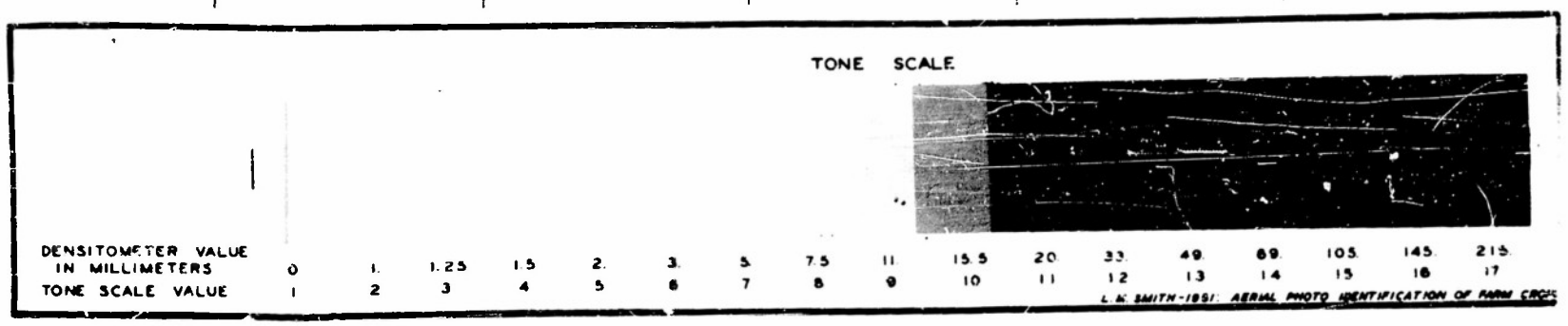


Figure 21